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The Wayfinding Questionnaire: A clinically useful self-report instrument to identify navigation complaints in stroke patients

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ABSTRACT

Post-stroke navigation complaints are frequent (about 30%) and intervention is possible, but there is no assessment instrument to identify patients with navigation complaints. We therefore studied the clinical validity of the Wayfinding Questionnaire (WQ) in a cross-sectional study with 158 chronic stroke patients and 131 healthy controls. Patients with low (more navigation complaints) versus normal WQ scores were compared for demographics, stroke characteristics, emotional and cognitive complaints, and health-related quality of life (HRQoL). Actual navigation performance of 78 patients was assessed in a virtual reality setting. Effect sizes (d) were calculated. WQ responses (22 items) of stroke patients were compared with those of controls (discriminant validity). Results showed that patients with a low WQ score ($n = 49$, 32%) were more often women ($p = 0.013$) and less educated ($p = 0.004$), reported more cognitive complaints ($d = 0.69$), more emotional problems ($d = 0.38$ and 0.52), and lower HRQoL ($d = 0.40$ and 0.45) and, last but not least, performed worse on the navigation ability tasks ($d = 0.23$ – 0.80). Patients scored lower than controls on 21/22 WQ items, predominantly with small to medium effect sizes ($d = 0.20$ – 0.51). We conclude that the WQ is valid as a measure of navigation complaints in stroke patients, and thus strongly advocate its use in stroke care.

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Introduction

Our brain uses a range of cognitive skills when moving around in a particular environment, the so-called spatial navigation ability. This complex cognitive construct is crucial

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because it enables us to adapt to new environments and allows us to move from one point to another in our daily lives, both indoors, from room to room, and outdoors, from home to the grocery store, to work or to visit family in a different town. Whilst navigation ability varies greatly among healthy people (Hegarty, Montello, Richardson, Ishikawa, & Lovelace, 2006), numerous case reports have described that individuals with brain damage are prone to experiencing navigation complaints (Aguirre & D'Esposito, 1999; Busigny et al., 2014; van der Ham et al., 2010). In a study of mild stroke patients in the chronic phase, 29% reported navigation complaints (van der Ham, Kant, Postma, & Visser-Meily, 2013). Unfortunately, navigation complaints are not routinely assessed in stroke patients nowadays; neither in history-taking nor in standard neuropsychological assessments. Existing questionnaires such as the checklist for cognitive and emotional consequences following stroke, the CLCE-24, do not address navigation complaints (van Heugten, Rasquin, & Winkens, 2007). Moreover, in previous literature very little correlation between scores on single cognitive domains from standardised neuropsychological examination tests and self-reported navigation impairment was found (van der Ham et al., 2013). We therefore think that difficulties in navigation ability are currently underdiagnosed.

The Wayfinding Questionnaire (WQ), a self-report questionnaire to assess navigation complaints, was first presented in 2013 (van der Ham et al., 2013). The development of the WQ was based on previous literature and inspired by existing questionnaires that only provided partial coverage of the concept of navigation ability. One of these questionnaires was a "sense-of-direction" 15-item scale (Hegarty, Richardson, Montello, Lovelace, & Subbiah, 2002). This scale, however, does not include any item on spatial anxiety (SA). Inclusion of the concept of SA is essential, because it negatively affects navigation ability, and might not be detected by instruments of general anxiety (Walkowiak, Foulsham, & Eardley, 2015). Another existing "sense of direction" scale with 22 items is the Familiarity and Spatial Cognitive Style Scale, which lacks a section about SA as well (Piccardi, Riseti, & Nori, 2011). Questionnaires that do include SA, like the Wayfinding Anxiety Scale and Lawton's Spatial Anxiety Scale, however, do not include other navigation complaints like distance estimation and orientation (Lawton & Kallai, 2002; Lawton, 1994). A 17-item International Wayfinding Strategy Scale focuses on orientation and route strategies, not on the ability to navigate (Lawton & Kallai, 2002). The coverage of the full range of navigation complaints is thus unique to the WQ.

The WQ was recently tested for internal validity in a large group of healthy controls and mild stroke patients. This study resulted in a final version of the WQ containing 22 items and taking less than 10 minutes to complete (Claessen, Visser-Meily, de Rooij, Postma, & van der Ham, 2016b). However, additional evidence to support its clinical usefulness in stroke patients is required for use in clinical practice.

Our aim was therefore to study whether the WQ can be used as an assessment tool to identify complaints concerning navigation ability in stroke patients. To assess whether the WQ is clinically valid, in other words clinically relevant and useful, we considered several aspects of validity that we think are important in clinical practice. We tested association hypotheses to validate the WQ because no gold standard is available. Hence, we analysed differences between stroke patients with a low WQ score and those with a normal WQ score regarding demographics, scores on other self-report instruments, and objective tests of navigation ability. Based on the literature, we hypothesised that women, older patients, and patients with more cognitive, anxious, or depressive complaints would have more navigation complaints (Coluccia & Louse, 2004; Moffat,

2009). Furthermore, we expected patients with more navigation complaints to perform worse on objective tests of navigation ability, and to report lower health-related quality of life (HRQoL), because navigation problems may interfere with independent functioning in daily life. We also used the WQ to explore which navigation complaints were most common in stroke patients, and analysed the differences in WQ responses between stroke patients and healthy controls (discriminant validity).

Methods

Design and participants

A cross-sectional study was performed including both stroke patients and healthy controls. The study was designed in accordance with the regulations provided by the Declaration of Helsinki. The study procedures were approved by the medical ethical review board of the University Medical Centre Utrecht (protocol number 12–198). The recruitment procedures have been described in detail elsewhere (Claessen, Visser-Meily, de Rooij, et al., 2016b). Briefly, 158 stroke patients were included who visited the rehabilitation centre or hospital rehabilitation department in Utrecht, the Netherlands. Inclusion criteria were: (1) first or recurrent stroke; (2) age ≥ 18 years; (3) ≥ 6 months since first stroke event, and (4) living at home after rehabilitation. Exclusion criteria were: (1) unable to communicate in Dutch, (2) severe global aphasia, and (3) severe mobility problems (i.e., patients had to be able to walk outside without supervision). Healthy controls were recruited for several study objectives, including the WQ. For this study, we used data of 131 controls. Sixty-seven of them completed only the WQ, while 64 completed the WQ as part of the same set of questionnaires as the stroke patients. These control groups were comparable with respect to age and gender.

Data collection

All stroke patients and 64 controls completed a set of paper/pencil self-report questionnaires described below (concerning complaints on navigation, cognition, emotions and quality of life). Demographic characteristics collected included age, gender, and level of education (1 “primary education completed” up to 7 “university education completed”) (Verhage, 1964). Stroke characteristics were obtained from medical files and included type of stroke, hemisphere involved, and date of stroke.

Navigation complaints

The Wayfinding Questionnaire (WQ) contains 22 items in 3 subscales: navigation and orientation (NO, 11 items), distance estimation (DE, 3 items) and spatial anxiety (SA, 8 items) with scores ranging from 1 to 7, and is displayed in [Appendix 1](#). A lower score indicates more navigation complaints for all items (all 8 SA item scores were reversed). The subscale scores for NO (range 7 to 77), DE (range 3 to 21) and SA (range 8 to 56) represent different aspects of the “navigation ability” function and are not combined in one total score.

Cognitive complaints

The cognitive domain of “memory and thinking” of the Stroke Impact Scale version 3.0 (c-SIS) was used to assess self-reported cognitive problems (Duncan, Bode, Lai, & Perera,

2003). This domain consists of seven items and each item is scored from 1 (“not difficult at all”) to 5 (“cannot do at all”). Some examples of the items are: “In the past week, how difficult was it for you: to remember things that people just told you, to remember things that happened the day before, to concentrate.” The scale score is the average of the item scores and a higher score indicates more problems of memory and thinking. The SIS has been shown to have excellent psychometric properties in terms of concurrent and construct validity, test-retest reliability and responsiveness (Carod-artal, Coral, Trizotto, & Moreira, 2008; Duncan et al., 2003).

Emotional complaints

The Hospital Anxiety and Depression Scale (HADS) was used to assess emotional functioning in terms of depressive (7 items) and anxiety symptoms (7 items). The total score of all 14 items ranges from 0 to 42. A higher score indicates more emotional problems (Zigmond & Snaith, 1983). The HADS has shown good psychometric properties and is commonly used for stroke patients (Spinoven et al., 1997; Zigmond & Snaith, 1983).

Health related quality of life (HRQoL)

The short-version of the Stroke-Specific Quality of Life Questionnaire (SS-QoL-12) was used to assess HRQoL. This is a validated disease-specific measure that contains five items on physical and seven items on psychosocial HRQoL, each scored on a 5-point scale (Post et al., 2011). Items are averaged to obtain a total score (range 1 to 5), higher scores indicating better HRQoL. In the control group, an adapted version of the SS-QoL-12 was used without the words “due to stroke” in the introduction sentence.

Navigation cognitive ability tasks

A subset of the stroke patients ($n = 78$) were assessed for navigation ability in a virtual reality setting using the Virtual Tübingen test (Claessen, Visser-Meily, de Rooij, et al., 2016b; Claessen, Visser-Meily, Jagersma, Braspenning, & van der Ham, 2016; van Veen, Distler, Braun, & Bühlhoff, 1998). The patients were twice shown a video of a virtual route through a photorealistic rendition of the German city Tübingen on a laptop screen (17.3-inch diagonal HD4 display). The video displayed the virtual route from an egocentric (viewer-based) perspective. The patients were requested to remember as many aspects of this route as possible, after which they performed eight subtasks. *Scene Recognition* was tested by presenting 22 images of decision points taken from the route (11 targets and 11 distractors). Patients were requested to indicate if the decision points had been in their route. Scoring was based on the number of correct responses, range 0–22. *Route Continuation* was assessed by presenting 11 decision points taken from the route one-by-one in random order and asking participants to indicate the direction in which the route continued at each decision point. Scoring was based on the number of correct responses, range: 0–11. To test *Route Sequence* patients were requested to indicate the sequence of turns taken during the route, by arranging a set of arrow cards. Scoring was based on the number of correctly indicated turns in the sequence, range 0–7. *Route Order* was tested by instructing the patients to reconstruct the order in which 11 images of decision points occurred during the route. Scores ranged from 0–22. *Route Progression* tested memory for absolute order of scenes. Patients were shown 11 printed images and were provided with a small piece

of paper with a printed line representing the length of the route. They were asked to indicate where each image was encountered on the route. Scoring was performed by calculating the relative difference between the correct position and the indicated position. These scores were averaged and varied between 0 and 1 (= perfect performance). For *Route Distance* patients were presented with two scenes and had to indicate the distance between these scenes on a line representing the total distance of the route. Scoring was the average (9 trials) of the percentage of deviation between the indicated and actual position relative to the full length of the line. *Route Drawing* was tested by asking the patients to draw the route they had studied on a map of the test environment, in which only the starting point and starting direction were provided. Scoring ranged from 0 to 11, one point for each correctly indicated direction (left turn, straight ahead or right turn) at relevant decision points. For *Map Recognition* the patients had to select the correct map of the route out of four options. Scoring was dichotomous (correct or incorrect).

Analyses

A cut-off value can help health care professionals to decide which score indicates clinically meaningful problems. Such cut-off values are frequently based on empirical findings, not on theoretical arguments, e.g., the Centre for Epidemiologic Studies Depression Scale (Shinar, Gross, Bolduc, & Robinson, 1986). We chose cut-off values corresponding to the lower (most severe) 5% WQ scores for each subscale in the 131 healthy controls, by Z-score of <-1.64 (Lezak, Howieson, Bigler, & Tranel, 2012). WQ subscale scores were considered low if: ≤ 32 for NO, ≤ 6 for DE and ≤ 20 for SA.

Patients were classified as having navigation problems (low WQ score) if they had a low score on one or more subscales. Subsequently, we compared the patients with a normal and those with a low score regarding demographics, stroke characteristics, cognitive and emotional complaints, and HRQoL. Effect sizes were defined as by Cohen (small effect $d = 0.2$ – 0.49 , medium effect $d = 0.5$ – 0.79 , and large effect $d \geq 0.8$). Independent T-test or Chi-square test was used to identify significant differences. Additionally, Spearman correlation was calculated between the mean scores for each WQ category and the HADS score. A correlation of <0.3 was considered weak, 0.3 to 0.6 moderate, and >0.6 good.

Next, we analysed whether the patients with low WQ scores did indeed score lower on the Virtual Tübingen test than patients with WQ scores in the normal range. Effect sizes (d) and the significance of differences was calculated with Cohen's d , T-test or Chi-square test.

Finally, we compared the WQ scores of the 158 stroke patients with those of the 131 healthy controls (discriminant validity). Because navigation ability can be low in healthy people as well, and not all stroke patients will have navigation problems, we analysed the mean differences between patients and controls, and did not attempt to separate sick from healthy. Mean scores were calculated for the 22 individual items and the 3 composite subscales. Effect sizes (d) and levels of significance were again calculated with Cohen's d , and T-test or Chi-square test. To explore the most frequent navigation complaints, we additionally dichotomised all item scores, considering item scores ≤ 3 ("not at all /almost never /rarely applicable to me") as indicating navigation complaints and item scores ≥ 4 ("sometimes /often /almost always /fully applicable to me") as indicating no navigation complaints.

Results

Baseline characteristics of the 158 stroke patients and 131 healthy controls are presented in [Table 1](#). There were some differences in gender, age, and education between the two groups, the control group including more males, while controls were slightly younger and had somewhat higher level of education. There were obvious differences in c-SIS, HADS, and SSQoL-12 scores ($p < 0.001$) between stroke patients and controls. Missing data for three stroke patients meant that no reliable assessment was available to determine whether their WQ score was low or normal. We found 49/155 (32%) stroke patients having a low WQ score on one or more subscales ([Table 1](#)). Of the patients with a low WQ score, 27/49 (55%) scored low on one subscale (6 NO, 7 DE, 14 SA), while 22/49 (45%) scored low on more than one subscale (9 on NO + DE, 2 on NO + SA, 2 DE + SA and 9 on all three subscales). In the control group we found 14% having a low score on one or more subscales.

Differences between patients with low versus normal WQ score are presented in [Table 1](#). The group with low WQ scores included significantly more women, lower educated patients and patients with more cognitive complaints (higher c-SIS, $d = 0.69$), more emotional problems (higher HADS, $d = 0.38$ and 0.52) and lower HR-QoL (lower SS-QoL, $d = 0.40$ and 0.45). Age, type of stroke, location of stroke, and time after stroke were not significantly different between groups. Spearman correlations between the HADS and WQ subscales were weak-to-moderate, the highest for SA and HADS-anxiety: HADS and SA -0.41 (anxiety) and -0.33 (depression), HADS and NO -0.30 (anxiety) and -0.33 (depression), and HADS and DE -0.20 (anxiety) and -0.21 (depression). These correlations were significant at the 0.01 level, except that for DE and HADS-anxiety (0.05 level).

Differences in performance on the Virtual Tübingen Test are shown in [Table 2](#). Data were available for 30 (61%) of the patients with a low WQ score and 48 (45%) of the patients with normal WQ score. Performance was significantly poorer in the patients with a low WQ score compared to patients with a normal WQ score for all eight navigation tasks. Effect sizes were small for four tests ($d = 0.2$ – 0.5) and medium to large for three tests ($d = 0.6$ – 0.8). In one test d could not be calculated, but the difference was significant as well ($p = 0.017$).

Differences in WQ responses between stroke patients and controls are listed in [Table 3](#). Stroke patients scored lower than controls on 21/22 items, and these differences were significant for 14 items. Effect sizes were small-to-medium ($d = 0.2$ – 0.5), with the largest difference for item 21 "I enjoy taking new routes (for example shortcuts) to known destinations" ($d = 0.51$, $p < 0.001$). All three subscales showed significant differences between stroke patients and controls with d values of 0.35 for NO, 0.24 for DE and 0.45 for SA. The percentages of stroke patients scoring ≤ 3 on the various items were also higher compared to the controls, except for item 20. The difference was ≥ 10 percent for 14 items (64%), and ≥ 15 percent for 10 items (45%). The largest differences were 20–28% for items 5, 10, 13, 14, and 21. Difference for NO was 8%, for DE 17% and for SA 12% ([Table 3](#)).

Because the baseline characteristics of patients and controls ([Table 1](#)) revealed significant differences in gender, age, and education, we additionally compared mean scores on the three WQ subscales for gender, dichotomised age, and dichotomised level of education of patients and controls ([Table 4](#)). We found that patients scored lower than controls in all six comparisons. Women generally had a lower WQ score

Table 1. Baseline characteristics of stroke patients and healthy controls, and differences between patients with low versus normal Wayfinding Questionnaire scores.

	Healthy controls	Stroke patients	Significant difference? ^a	Stroke patients with normal WQ ^b	Stroke patients with low WQ ^b	Effect size Cohen's d and significant difference ^a
Number of patients/controls	<i>N</i> = 131	<i>N</i> = 158		<i>N</i> = 106 (68%)	<i>N</i> = 49 (32%)	
Gender , male	55 (42%)	94 (59%)	0.03	70 (66%)	22 (45%)	<i>p</i> = 0.013
Age in years , mean (range)	57.0 (37–87)	60.0 (22–96)	0.03	59.4 ± 13.3 (27–96)	61.0 ± 12.9 (50–83)	0.12 <i>p</i> = 0.502
Education ^c , mean (range 1–7)	5.7 (SD 0.82)	5.2 (SD 1.40)	<0.001	5.4 ± 1.2	4.6 ± 1.6	<i>p</i> = 0.004
Stroke type						
– Ischemic stroke	–	113 (71%)	–	75 (71%)	35 (72%)	–
– Haemorrhagic stroke	–	22 (14%)		16 (15%)	6 (12%)	
– Intracerebral						
– Subarachnoid	–	4 (3%)		3 (3%)	1 (2%)	
– Unspecified/unavailable	–	19 (12%)		12 (11%)	7 (14%)	
Stroke location						
– Left	–	72 (46%)	–	48 (45%)	24 (49%)	–
– Right	–	52 (33%)		37 (35%)	13 (27%)	
– Bilateral	–	8 (5%)		4 (4%)	4 (8%)	
– Unspecified/unavailable	–	26 (16%)		17 (16%)	8 (16%)	
Time after stroke in months (mean, SD)	–	45 (SD 30.4) <i>Missing</i> 21	–	46 (SD 30.5) <i>Missing</i> 11	43 (SD 31.1) <i>Missing</i> 9	0.10 <i>p</i> = 0.696
Cognitive complaints ^d	1.54 (SD 0.47)	2.21 (SD 0.84)	<0.001	2.04 (SD 0.69)	2.62 (SD 1.00)	–0.69 <i>p</i> < 0.0001
Stroke Impact Scale, memory and thinking parts (mean and SD, range 1–5)	<i>N</i> = 64	<i>Missing</i> 1			<i>Missing</i> 1	
Anxiety complaints ^d	2.86 (SD 2.46)	5.23 (SD 4.23)	<0.001	4.74 (SD 4.00)	6.35 (SD 4.58)	–0.38 <i>p</i> = 0.029
Hospital Anxiety and Depression Scale, Anxiety parts (mean and SD, range 0–21)	<i>N</i> = 64	<i>Missing</i> 4		<i>Missing</i> 3		
Depressive complaints ^d	2.00 (SD 2.35)	5.22 (SD 4.08)	<0.001	4.57 (SD 3.51)	6.78 (SD 4.91)	–0.52 <i>p</i> = 0.008
Hospital Anxiety and Depression Scale, Depression parts (mean and SD, range 0–21)	<i>N</i> = 63	<i>Missing</i> 6		<i>Missing</i> 3	<i>Missing</i> 3	
	4.91 (SD 0.21) <i>N</i> = 64	4.17 (SD 0.82) <i>Missing</i> 6	<0.001	4.27 (SD 0.77) <i>Missing</i> 3	3.94 (SD 0.90) <i>Missing</i> 3	0.40 <i>p</i> = 0.025

Quality of Life, physical^d						
Stroke Specific Quality of Life Scale (mean and SD, range 1–5)						
Quality of Life, psychosocial^d	4.75 (SD 0.35)	3.60 (SD 0.99)	<0.001	3.73 (SD 0.96)	3.28 (SD 1.02)	0.45 $p = 0.009$
Stroke Specific Quality of Life Scale (mean and SD, range 1–5)	<i>N = 64</i>	<i>Missing 5</i>		<i>Missing 2</i>	<i>Missing 3</i>	

^aIndependent T-test was used or Chi-square-test in case of dichotomous outcomes; $p < 0.05$ is a significant difference. Cohen's d effect sizes, with 0.2 indicating a small, 0.5 a medium, and 0.8 a large effect. Cohen's d was not calculated in case of dichotomous outcomes.

^bLow WQ in stroke patients is defined as a Z score < -1.64 on at least one subscale. See text (Methods) for further explanation. Missing data points for 3 stroke patients mean that no reliable assessment was available to determine whether their WQ score was low or normal.

^cEducation: The education level was based on Verhage (1964); a higher score means higher education level. See text (Methods) for further explanation.

^dFor cognitive, anxiety, and depressive complaints, a higher score indicates more cognitive problems, more anxious emotions, more depressive emotions. On the Quality of Life Scale (SSQoL), a higher score indicates better quality of life. See text (Methods) for further explanation.

Table 2. Navigation ability performance on the Virtual Tübingen test in stroke patients with normal Wayfinding Questionnaire (WQ) score versus low WQ score^a

Navigation ability tasks ^a	Stroke patients with normal WQ score	Stroke patients with low WQ score	Effect size Cohen's d and significant difference ^b
Number of patients	48 (45%)	30 (61%)	
Scene Recognition (mean, range 1–22)	16.89 (SD 2.28) <i>Missing 1</i>	15.90 (SD 2.78)	0.39 $p = 0.091$
Route Continuation (mean, range 1–11)	7.19 (SD 1.95)	6.57 (SD 2.14)	0.30 $p = 0.192$
Route Sequence (mean, range 1–7)	3.71 (SD 1.87)	2.53 (SD 1.87)	0.63 $p = 0.009^*$
Route Order (mean, range 1–22)	8.21 (SD 4.96)	6.13 (SD 3.55)	0.49 $p = 0.050^*$
Route Progression (mean, range 0.0–1.0)	0.794 (SD 0.072)	0.734 (SD 0.079)	0.80 $p = 0.001^*$
Route Distance (mean, range 0.0–1.0)	0.791 (SD 0.080)	0.744 (SD 0.076)	0.60 $p = 0.013^*$
Route Drawing (mean, range 1–11)	4.06 (SD 3.11)	3.43 (SD 2.29)	0.23 $p = 0.308$
Map Recognition (mean, score 0 or 1)	0.49 (SD 0.51) <i>Missing 1</i>	0.27 (SD 0.45)	$p = 0.017^*$

^aA subset of the stroke patients had their navigation ability tested in a virtual reality setting. See text for explanation of the navigation subtasks.

^bIndependent T-test was used, $*p < 0.05$ is a significant difference. Cohen's d effect sizes with 0.2 indicating a small, 0.5 a medium, and 0.8 a large effect. Cohen's d was not calculated in case of dichotomous outcome.

than men on all three subscales, but the difference between patients and controls was found for both men and women on all three subscales, most obviously for SA among men. Women with stroke had the lowest scores on DE (mean 3.31). Older participants generally had a higher WQ score, especially among the controls. Differences between patients and controls were largest for older participants, most obviously for NO. Participants with a low education generally had a lower WQ score. Differences between patients and controls were found in both high and low educated persons for all three subscales, most obviously for SA among the highly educated participants.

Discussion

Our study ensues from previous research on the validation of the Wayfinding Questionnaire (WQ) as a clinically useful instrument to identify complaints about navigation ability in stroke patients (Claessen, Visser-Meily, de Rooij, et al., 2016b). The hypothesised associations that we regard as being clinically relevant were sufficiently confirmed. As expected, the stroke patients with a low WQ score were more likely to be women, reported more cognitive complaints, more emotional problems, and lower HRQoL, and most importantly, also performed less well on the navigation ability tasks. The proportion of stroke patients with navigation complaints (low WQ scores on one or more subscales; 32%) was similar to the 29% found earlier in another sample of stroke patients (van der Ham et al., 2013), and considerably higher than in the healthy control group (14%). We also confirmed the WQ's discriminant validity: patients generally scored lower than healthy controls on all 3 subscales.

To our knowledge, no assessment instrument other than the WQ is available to cover the complete cognitive complexity that characterises navigation complaints. Our three-subscale structure, providing separate interpretations for navigation and orientation,

Table 3. Wayfinding Questionnaire responses: stroke patients versus healthy controls

ITEMS			
Range 1 to 7, a lower score indicating more navigation complaints A score of ≤ 3 was defined as indicating clinically relevant complaints ^a	Patients, <i>N</i> = 158 Mean score (SD), % with complaints ^a	Controls, <i>N</i> = 131 Mean score (SD), % with complaints ^a	Effect size Cohen's <i>d</i> and significant difference ^b
1. When I am in a building for the first time, I can easily point to the main entrance of this building.	4.30 (1.9), 29%	4.44 (1.8), 28%	0.08 ($p = 0.527$)
2. If I see a landmark (building, monument, intersection) multiple times, I know exactly from which side I have seen that landmark before.	4.86 (1.8), 22%	5.18 (1.6), 15%	0.19 ($p = 0.115$)
3. In an unknown city I can easily see where I need to go when I read a map on an information board.	4.59 (2.0), 32%	5.28 (1.7), 15%	0.37 ($p = 0.001$)*
4. Without a map, I can estimate the distance of a route I have walked well, when I walk it for the first time.	3.92 (2.0), 40%	4.25 (1.7), 32%	0.18 ($p = 0.123$)
5. I can estimate well how long it will take me to walk a route in an unknown city when I see the route on a map (with a legend and scale).	3.82 (2.0), 44%	4.48 (1.5), 22%	0.38 ($p = 0.001$)*
6. I can always orient myself quickly and correctly when I am in an unknown environment.	3.93 (2.0), 41%	4.51 (1.6), 26%	0.32 ($p = 0.006$)*
7. I always want to know exactly where I am (meaning, I am always trying to orient myself in an unknown environment).	4.76 (1.9), 29%	5.04 (1.6), 17%	0.16 ($p = 0.179$)
8. I am afraid of losing my way somewhere. ^c	4.46 (2.1), 32%	5.23 (1.8), 19%	0.39 ($p = 0.001$)*
9. I am afraid of getting lost in an unknown city. ^c	4.48 (2.1), 34%	5.14 (1.8), 24%	0.34 ($p = 0.005$)*
10. In an unknown city, I prefer to walk in a group rather than by myself. ^c	4.03 (2.4), 45%	4.89 (2.0), 25%	0.39 ($p = 0.001$)*
11. When I get lost, I get nervous. ^c	4.25 (2.2), 40%	4.85 (1.8), 26%	0.30 ($p = 0.013$)*
How uncomfortable are you in the following situation (12,13,14):			
12. Deciding where to go when you are just exiting a train, bus, or subway station. ^c	4.56 (1.9), 31%	4.95 (1.7), 22%	0.21 ($p = 0.070$)
13. Finding your way in an unknown building (for example a hospital). ^c	4.62 (2.0), 31%	5.46 (1.5), 9%	0.48 ($p < 0.001$)*
14. Finding your way to a meeting in an unknown city or part of a city. ^c	3.91 (2.0), 46%	4.74 (1.7), 26%	0.45 ($p < 0.001$)*
15. I find it frightening to go to a destination I have not been before. ^c	4.73 (2.0), 27%	5.44 (1.8), 18%	0.37 ($p = 0.002$)*
16. I can usually recall a new route after I have walked it once.	4.32 (2.0), 35%	4.50 (1.8), 27%	0.09 ($p = 0.415$)
17. I am good at estimating distances (for example, from myself to a building I can see).	4.41 (1.9), 32%	4.52 (1.6), 24%	0.06 ($p = 0.582$)
18. I am good at understanding and following route descriptions.	4.42 (2.0), 27%	5.18 (1.5), 12%	0.43 ($p < 0.001$)*
19. I am good at giving route descriptions (meaning, explaining a known route to someone).	4.48 (1.9), 32%	5.04 (1.5), 15%	0.33 ($p = 0.006$)*
20. When I exit a store, I do not need to orient myself again to determine where I have to go.	4.82 (2.0), 25%	4.69 (1.9), 30%	-0.07 ($p = 0.579$)

(Continued)

Table 3. Continued.

ITEMS			
Range 1 to 7, a lower score indicating more navigation complaints A score of ≤3 was defined as indicating clinically relevant complaints ^a	Patients, <i>N</i> = 158 Mean score (SD), % with complaints ^a	Controls, <i>N</i> = 131 Mean score (SD), % with complaints ^a	Effect size Cohen's <i>d</i> and significant difference ^b
21. I enjoy taking new routes (for example shortcuts) to known destinations.	3.97 (2.2), 45%	4.96 (1.8), 17%	0.51 (<i>p</i> < 0.001)*
22. I can easily find the shortest route to a known destination.	4.52 (2.1), 33%	5.14 (1.6), 16%	0.34 (<i>p</i> = 0.004)*
SUBSCALES			
Navigation and orientation (11 items): 1,2,3,6,7,16,18,19,20,21,22	4.45 (1.4), 17% Missing 2	4.90 (1.2), 9% Missing 2	0.35 (<i>p</i> = 0.004)*
Distance estimation (3 items): 4,5,17	4.05 (1.7), 34% Missing 2	4.42 (1.4), 17% Missing 1	0.24 (<i>p</i> = 0.041)*
Spatial anxiety (8 items): 8,9,10,11,12,13,14,15	4.37 (1.7), 25% Missing 1	5.07 (1.4), 13% Missing 3	0.45 (<i>p</i> < 0.001)*

^aA score of ≤3 was defined as a clinically relevant complaint. See text (Methods) for further explanation. Briefly: a score of 1–3 included the responses “not at all / almost never / rarely applicable”, compared to 4 or higher “sometimes/often/almost always/fully applicable”.

^bIndependent T-test was used, **p* < 0.05 is a significant difference. Cohen's *d* effect sizes with 0.2 indicating a small, 0.5 a medium, and 0.8 a large effect.

^cThe score for these items was reversed, so for all items a lower score indicates more navigation complaints.

distance estimation, and spatial anxiety, is thus unique (Claessen, Visser-Meily, de Rooij, et al., 2016b). Our research group is also the first to measure navigation complaints in a large group of stroke patients. More than three-quarters of our patients with low WQ scores were affected in terms of 1 or 2 subscales of this instrument, while only a minority scored low on all three subscales. The different subscales are needed for stroke patients as the different complaints might require different treatment strategies.

Literature on the subject of spatial navigation that describes findings agree with our results regarding demographic differences. The women in our cohort had a higher level of NO, DE and SA complaints than the men, both among the controls and the stroke patients (Table 4). All three subscales showed more complaints among patients than controls, both for men and women. The greatest difference between patients and controls was that regarding SA for the men (*d* = 0.63) and that regarding SA for the women (*d* = 0.51). A large review on gender and navigation has described differences in strategies, with men preferably relying on visuospatial properties of the environment and configurational orientation strategies, while women focus more on landmarks and procedural “route” strategies involving route knowledge (Coluccia & Louse, 2004). The same review discussed differences in the findings of self-evaluation questionnaires on orientation skills, in which men estimate themselves to be better at orientation and show greater confidence in their ability than women. In other words, lower self-confidence (or more honesty to admit failures) might increase the navigation complaints among women. The authors also stated that women report more anxiousness when navigating than men, which agrees with our findings. Our SA subscale might be a good measure of low confidence in one's navigation ability, due to personality (or changes therein), more fear of getting lost after stroke and/or loss of cognitive navigation skills after stroke. Interestingly, our results reveal that SA is negatively influenced by stroke not only for women, but also (or relatively even more strongly) for men. In our study, the expected

**Table 4.** Comparison of mean scores on the three subscales for different gender, age, and education level (patients versus healthy controls)

Three WQ subscales (mean score, SD)	Effect size Cohen's d and significant difference ^a				Effect size Cohen's d and significant difference ^a			
GENDER	Men patients n = 94	Men controls n = 55			Women patients n = 64	Women controls n = 75		
navigation & orientation	4.77 (1.40)	5.36 (0.92)	0.51	<i>p</i> = 0.003*	4.00 (1.32)	4.56 (1.23)	0.44	<i>p</i> = 0.011*
distance estimation	4.54 (1.56)	4.98 (1.09)	0.33	<i>p</i> = 0.048*	3.31 (1.60)	4.01 (1.44)	0.46	<i>p</i> = 0.008*
spatial anxiety	4.68 (1.64)	5.59 (1.23)	0.63	<i>p</i> < 0.001*	3.90 (1.64)	4.68 (1.44)	0.51	<i>p</i> = 0.004*
AGE	Young, age <60y patients n = 74	Young, age <60y controls n = 82			Older, age ≥60y patients n = 83	Older, age ≥60y controls n = 49		
navigation & orientation	4.47 (1.31)	4.70 (1.22)	0.18	<i>p</i> = 0.259	4.44 (1.52)	5.25 (1.02)	0.64	<i>p</i> < 0.001*
distance estimation	3.98 (1.70)	4.21 (1.49)	0.14	<i>p</i> = 0.376	4.11 (1.67)	4.77 (1.13)	0.47	<i>p</i> = 0.015*
spatial anxiety	4.46 (1.52)	5.03 (1.45)	0.38	<i>p</i> = 0.017*	4.28 (1.81)	5.12 (1.41)	0.52	<i>p</i> = 0.007*
EDUCATION	High education patients n = 68	High education controls n = 83			Low education patients n = 90	Low education controls n = 47		
navigation & orientation	4.66 (1.42)	5.06 (1.11)	0.32	<i>p</i> = 0.053	4.30 (1.41)	4.61 (1.24)	0.23	<i>p</i> = 0.209
distance estimation	4.23 (1.65)	4.64 (1.30)	0.28	<i>p</i> = 0.100	3.91 (1.70)	4.04 (1.48)	0.08	<i>p</i> = 0.670
spatial anxiety	4.54 (1.65)	5.30 (1.42)	0.50	<i>p</i> = 0.003*	4.23 (1.69)	4.65 (1.36)	0.28	<i>p</i> = 0.150

^aIndependent T-test was used, $*p < 0.05$ is a significant difference. Cohen's d effect sizes with 0.2 indicating a small, 0.5 a medium, and 0.8 a large effect.

correlation between lower WQ score and higher age was not found (Moffat, 2009). This is, however, in line with other studies suggesting that older individuals overestimate their current navigation abilities. It could be that seniors tend to judge their sense of direction and everyday navigation just as favourably or even more so than the younger generations (Klencklen, Després, & Dufour, 2012; Taillade, Kaoua, Sauzéon, & Rosa, 2016).

We found more self-reported navigation problems among patients with more cognitive complaints (Table 1). This was to be expected, as navigation ability is a complex cognitive function, related to a multitude of other cognitive abilities such as episodic memory, mental working speed, and executive functioning (Wolbers & Hegarty, 2010). Navigation complaints and cognitive complaints as assessed by the c-SIS can coincide, but it is important to keep in mind that navigation is a dissociable cognitive function, so navigation complaints can also be present without complaints in other cognitive domains. As regards emotional feelings, more navigation complaints were reported by patients in our study with more anxious and depressive complaints, and moderate correlations between SA score and the HADS-anxiety were found. It is important to mention once again that SA assessment offers additional value to the HADS, because SA is not always found by instruments of general anxiety (Walkowiak et al., 2015). We found that lower WQ scores were associated with lower levels of both psychosocial and physical HRQoL. This could be explained by the fact that navigation complaints interfere with independent functioning and mobility. In conclusion, the fact that our hypothesised associations between navigation and cognitive and emotional complaints and HRQoL were confirmed supports the validity of the WQ. Another relevant finding is the absence of difference in navigation complaints between locations of stroke (right versus left-sided lesions). This finding (suggesting that besides the right hemisphere, also the left hemisphere might be of importance in spatial processing) is beyond the scope of our study. The absence in difference on navigation performance between right and left-sided lesions was found in several previous studies as well and is comprehensively discussed in one of these studies (Claessen, Visser-Meily, Jagersma, et al., 2016).

Last but not least, the validity of the WQ was supported by our positive results using objective measurements of navigation ability: the patient group with a low WQ indeed showed poorer actual navigation performance in a virtual reality setting, with medium to large effect sizes. Although navigation ability in a virtual reality setting is different from that in a patient's personal surroundings, it is known that the Virtual Tübingen test provides an ecologically valid way to test real-life navigation ability (Claessen, Visser-Meily, de Rooij, Postma, & van der Ham, 2016a).

Strengths and limitations

A strength of our study is the large group of mild stroke patients in the chronic phase and the comparison with healthy controls. The group consisted of patients with various stroke types and locations, allowing generalisation to stroke patients in general. Our patient group was representative of the largest group of stroke patients living at home in the chronic phase. This group includes patients who were discharged directly to their own homes several days after the stroke, but also patients who initially had a severe hemiparesis and/or other neurological deficits in the subacute phase, but who can walk independently notwithstanding these neurological deficits after discharge

from a rehabilitation centre. In the chronic phase, this group of patients is confronted with navigation ability on daily basis. We were able to confirm our hypothesised associations between navigation complaints and demographics and other self-report instruments, with relevant effect sizes (small to medium effects). What is also unique to this study is that we performed analyses with both subjective and objective instruments of navigation ability. Objective measurement was based on performance on navigation cognitive ability tasks with the Virtual Tübingen test.

Our study also has some limitations. Our cut-off values should be interpreted with care, because they are based on a group of 131 participants and our control group included more men and younger persons with somewhat higher level of education compared to the stroke patients. However, [Table 4](#) shows that the crude mean WQ scores for dichotomised gender, age, and education each show differences between patients (lower WQ) and controls. Considering the above, we do not think that the differences in gender, age, and education between the groups have greatly biased our main results. Another limitation is that we did not calculate specificity and sensitivity values. This is, however, related to the fact that navigation complaints are also present in healthy people and there is no gold standard. It is therefore impossible to confirm full discriminant validity of the WQ, but future research will also not be able to prove this. A debatable issue is that a low score on the WQ might result from motor impairment or neglect caused by stroke, or is negatively influenced by cognitive or emotional dysfunction. Although we cannot fully invalidate this, we consider it unlikely in our study since we included a patient group with a relatively good outcome (walkers, independent in activities of daily living and without language disorder). Moreover, we hold that navigation ability and its complaints are not strongly depended on cognitive and emotional complaints since in additional analysis we found only small or even absent correlations between the Virtual Tübingen tests and cognitive/emotional complaints (data not shown). Additionally, although patients with a low WQ score reported more cognitive and emotional complaints, the ranges were nearly similar, meaning large individual variety within this group of patients. In other words, there are stroke patients without complaints about anxiety, depression or cognitive functioning that have self-reported navigation complaints, and vice versa. Another limitation is that in the current research the navigation ability was tested only in a novel environment, and not in a familiar environment. We did not perform a correction for multiple comparisons and therefore cannot fully exclude a possible influence of the high number of different comparisons on the results. However, we found so many significant differences that it seems unlikely that they can be explained by multiple testing only. In addition, we did not base our conclusions purely on significance but rather on size of the differences found. Finally, a general limitation of every self-reported instrument is that scores rely on accuracy of the patient's insights. Patients with brain injury may have diminished insights into their actual cognitive and navigation performance in daily life, due to their stroke as well as their age (Boosman, van Heugten, Winkens, Heijnen, & Visser-Meily, 2014). The above limitations are processed below in the clinical implications.

Clinical implications

We are convinced that the WQ can already be used in current practice, and future studies will be helpful to improve its interpretation (see next section). We recommend using the WQ in outpatient rehabilitation settings. It can be used in addition to other

instruments assessing post-stroke cognitive complaints, such as the CLCE-24 (van Heugten et al., 2007). Our cut-off values (NO sum score ≤ 32 , DE sum score ≤ 6 , or SA sum score ≥ 20) are helpful to guide the interpretation of WQ scores, but should not to be applied too strictly. We think that individual health professionals can decide whether the WQ responses are abnormal or not, even without (gender- and age-specific) cut-off values. Health professionals should take account of three considerations regarding the WQ subscales: men tend to assess themselves as having higher navigation ability than women (as found in the current study), older people might overestimate themselves more than younger people (Klencklen et al., 2012; Taillade et al., 2016) and some patients lack insight into their own cognitive functions and might overestimate themselves (Boosman et al., 2014). It may be valuable to involve the partner or family of the patient in answering the questions if the patient's self-insight is affected, though some items of the WQ will be difficult to answer for proxies. Last but not least, we believe the impact of the navigation complaints should be taken into account to create a suitable interpretation. Hence we recommend that health professionals ask patients (and their proxies) whether their ability to navigate has declined compared to the pre-stroke period and whether this decline is inconvenient to them. These two questions can help to decide whether a particular patient requires further diagnostics and/or treatment for their navigation complaints.

Treatment

Treatment options for navigation problems are currently being developed. An important intervention is that of psycho-education for both patients and their partners/family. Because navigation is such a complex cognitive function in which it is rare for all aspects to be affected, learning alternative navigation strategies can be a successful treatment option. A pilot navigation training programme using a virtual reality setting has shown good results in a small group of stroke patients (Claessen, van der Ham, Jagersma, & Visser-Meily, 2016). Patients can learn compensation strategies, but it depends on a patient's profile which compensation strategies are potentially useful. Whereas the WQ can help clinicians to establish whether objective assessment of navigation ability would be advisable, the Virtual Tübingen test gives a more extensive overview of the patient's strengths and weaknesses within navigation ability (a patient's profile). Whether our three WQ subscales by itself can be directly clinically used to determine a patient's navigational profile remains speculative. For example, it might be speculated that the training should be adapted based on the presence or absence of spatial anxiety. It could be that, in case of spatially anxious patients, other training techniques should be applied to restore confidence in their own wayfinding skills. Though theoretical, this might involve working towards small goals to increase chances of success or by applying errorless learning techniques. More research is needed to find out which patients might benefit from a navigation training focused on teaching them to adopt alternative navigation strategies. The WQ, as a short and valid screening instrument, would certainly be valuable for this future research.

Future research

We suggest that confirmation of our cut-off points in another large group of controls and stroke patients will be helpful to improve the interpretation of the WQ by health

professionals. It could be useful to define age- and gender-specific cut-off points or correction factors, but whether this is necessary is debatable. Next, although the WQ is already a concise questionnaire (less than 10 minutes), future studies could consider further shortening the WQ as regards the number of NO items, if studies should reveal (as the current one did) that item 20 shows no difference between patients and controls. Moreover, as navigation impairment also occurs in other types of acquired brain injury (traumatic brain injury) and degenerative diseases (Alzheimer's disease), future research can examine if the WQ is also clinically useful for these and other neurological patient groups.

Conclusion

The Wayfinding Questionnaire (WQ) is a valid and clinically useful self-report instrument for stroke patients to identify post-stroke navigation complaints (present in approximately 30% of stroke patients). The WQ is a fast and easy way to assist health care professionals in deciding whether or not a stroke patient should be referred for detailed objective navigation tests. This is important, as options for treatment of navigation problems are being developed. Although more research on cut-off values would be helpful, we already advocate the use of the WQ, to ensure navigation complaints in stroke patients are no longer ignored.

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Appendix 1

Wayfinding Questionnaire (WQ)

The following 22 statements are about navigation ability. For each of these statements, please

circle the number that best describes your ability to navigate.

The numbers 1 to 7 represent the following:

1	2	3	4	5	6	7
<i>Not at all applicable to me</i>	<i>Almost never applicable to me</i>	<i>Rarely applicable to me</i>	<i>Sometimes applicable to me</i>	<i>Often applicable to me</i>	<i>Almost always applicable to me</i>	<i>Fully applicable to me</i>

1. When I am in a building for the first time, I can easily point to the main entrance of this building.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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2. If I see a landmark (building, monument, intersection) multiple times, I know exactly from which side I have seen that landmark before.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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3. In an unknown city I can easily see where I need to go when I read a map on an information board.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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4. Without a map, I can estimate the distance of a route I have walked well, when I walk it for the first time.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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5. I can estimate well how long it will take me to walk a route in an unknown city when I see the route on a map (with a legend and scale).

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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6. I can always orient myself quickly and correctly when I am in an unknown environment.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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7. I always want to know exactly where I am (meaning, I am always trying to orient myself in an unknown environment).

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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8. I am afraid of losing my way somewhere.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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9. I am afraid of getting lost in an unknown city.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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10. In an unknown city, I prefer to walk in a group rather than by myself.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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11. When I get lost, I get nervous.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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How uncomfortable are you in the following situations (items 12, 13 and 14):

12. Deciding where to go when you are just exiting a train, bus, or subway station.

<i>Not uncomfortable at all</i>	1	2	3	4	5	6	7	<i>Very uncomfortable</i>
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13. Finding your way in an unknown building (for example a hospital).

<i>Not uncomfortable at all</i>	1	2	3	4	5	6	7	<i>Very uncomfortable</i>
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14. Finding your way to a meeting in an unknown city or part of a city.

<i>Not uncomfortable at all</i>	1	2	3	4	5	6	7	<i>Very uncomfortable</i>
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15. I find it frightening to go to a destination I have not been before.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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16. I can usually recall a new route after I have walked it once.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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17. I am good at estimating distances (for example, from myself to a building I can see).

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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18. I am good at understanding and following route descriptions.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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19. I am good at giving route descriptions (meaning, explaining a known route to someone).

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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20. When I exit a store, I do not need to orient myself again to determine where I have to go.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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21. I enjoy taking new routes (for example shortcuts) to known destinations.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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22. I can easily find the shortest route to a known destination.

<i>Not at all applicable to me</i>	1	2	3	4	5	6	7	<i>Fully applicable to me</i>
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